WARING (G. E.)

SEWERAGE

AND

SEWAGE DISPOSAL

AT

PROVIDENCE, R. I.

By Geo. E. Waring, Jr., M. Inst., C. E.

(Reprinted from the *American Architect*, January 24 and 31, 1885,)

NEWPORT, R. I.

SEWERAGE AND SEWAGE DISPOSAL AT PROVIDENCE.[1]

THIS large and elaborate report follows a tour of examination in Europe, made at the order of the City of Providence, by Samuel M. Gray, its City Engineer, assisted by Charles H. Swan, of Boston.

The investigations were made during the spring and early summer of 1884. Their chief purpose related to the disposal of town sewage, the object in view being to devise means for the relief of Providence River, which is now made most foul by the discharge of the sewers of the city. They included a personal examination of the principal works in England and on the Continent. To supplement the knowledge thus gained, schedules of questions were submitted to those in charge of works of sewage disposal. The replies from a certain number of towns, in response to these questions, are tabulated in three large supplement sheets published with the report.

Mr. Gray's investigations related both to the disposal of sewage, and to systems and processes of town sewerage and cleansing. These are described, and some of their details are illustrated by plates.

The ground covered includes not only the usual water-carriage systems of sewerage but the various methods of dry conservancy; the earth-closet, the movable tub, the ash-closet, the improved privy, the pail system and the Goux system; also the pneumatic systems of Liernur and of Berlier, and the pumping system of Shone.

Although containing little not already accessible in the literature of drainage engineering, this portion of the report is its best portion. It does not reach quite to the position of a hand-book, but it groups together in a convenient form much practical information. From the standpoint of the professional reader, the utility of this might well be questioned. It is really a thrashing of very old straw; we had been told most of it before, and more than once. In the direction toward which most of it trends, we had been told more than we find here. This, however, is not the standpoint from which this part of the work should be regarded.

The dead level of local tax-paying citizenship, probably as dead a

[1] *Proposed plan of a Sewerage System and for the Disposal of the Sewage of the City of Providence, R. I.*, by Samuel M. Gray, City Engineer. City Document, No. 25, 1884.

level in Providence as elsewhere, cannot be impressed by work done in and for the world at large. It must put its hand into its own pocket, and send afield its own engineer, whom it knows and trusts, and must make a good big book of the result of his researches and of his lucubrations. Then it is moved — and moved to some purpose. What it gets may not be so good as what it might have got for less money in some other way, but what it gets it believes in and will act on: and so the world gets forward.

From this point of view this publication may be justified.

Apropos of nothing in particular, as it turns out, much attention is given to the relative merits of the combined and separate systems of sewerage, the latter first suggested in 1842 by Mr. Edwin Chadwick, and first carried out by Phillips in 1850–51 at Alnwick and Tottenham. The report says: —

The experience of English engineers has led them to consider it impracticable to exclude the rain falling upon private property from the foul-water sewers, because this would require two sets of house-drains in many cases: one for sewage, connecting with the sewer, the other for the surface drainage of the yard and roof, and leading to other channels. They consider that it would cause many complications, and that it would be an unwarrantable exercise of authority to require the construction of two sets of house-drains. They also consider that the admission of a limited amount of rain-water to the foul-water sewers is an important factor in maintaining their cleanliness, and the prevailing practice with them, when separation is attempted, is to exclude only the rain-water in the streets and public squares, and to admit the rain-water from yards and the rear roofs of houses.

The practice in this country has tended towards a more complete separation of the sewage and the rainfall. This is due in part to the extreme views of some of the advocates of the separate system, and in part, no doubt, to the difference between the climates of the two countries; heavy rainfalls being more common here than in England.

The separation of the rainfall from the sewage becomes important when the sewage must finally be pumped, and when it must be treated chemically or used in irrigation. On the other hand, the separation of the sewage from the rainfall becomes important when the rainfall passes into streams that must afterwards serve as the sources of public water-supplies. These conditions, demanding separation, are frequently found associated together.

The question as to the necessity for separation, and of the proper method of removing storm water, is further complicated by the fact that the first wash of water after flowing over the streets of cities, being contaminated with the droppings of animals and other filth, becomes a variety of sewage possessing nearly, if not quite all the constituents of ordinary sewage, except the peculiar germs of disease asso-

ciated with human excrement, and except certain chemical products derived from manufacturing waste. By thorough and systematic scavenging, the streets may be kept in such a condition that the storm-water may cause little harm if permitted to pass directly into the streams; but this ideal of sanitary work is seldom attained, and the first washings of the streets during storms are usually extremely foul.

Another phase of the surface drainage of towns presents itself in the larger Northern cities in winter, when a thaw occurs after a long period of snow. The mingled accretions of snow, ice and filth, that have been weeks in accumulating, are then liberated in liquid form in great volumes, and require prompt removal. At such times the capacity of sewers receiving surface-water is severely taxed, ordinary surface channels are so obstructed as to require constant attention, and floodings frequently occur in lower districts, travel being greatly impeded, and property in basements and cellars being often damaged.

The great cost of sewers large enough to convey all the waters of heavy storms has already been referred to, it being prohibitory in most instances. Consequently the question as to the best method of removing storm-water is reduced to a consideration of the objections, from the sanitary or from the financial point of view, to the admission of a portion of the surface drainage to the sewers conveying sewage.

The advocates of the separate system claim, among other things, that some of the earthy matters carried into the sewers by turbid storm-water, particularly building-lime, act as precipitants and cause the deposit of organic matters within the sewers, intermixed with deposits of road detritus, leaves and twigs, brought into the sewers by storm-water. These deposits, when not removed by the ordinary flow of sewage or by flushings, must remain until the next heavy storm, and meanwhile become the source of noxious exhalations.

The essential difference between the two systems, as regards cleanliness and freedom from deposits, arises from the fact that in the separate system the substances to be removed are derived from domestic and manufacturing wastes, while in the combined system there are, in addition, the substances brought into the sewer by the storm-water. Thus, while the scouring power of the sewage in the combined sewers is, at best, no greater than in the separate sewers, and may in certain cases be less, the amount of deposits in them may be greater, and their nature may be such as to render them more difficult of removal. Another result derived from the use of small pipes, as in the separate system, is that a given volume of water, such as the contents of a flush-tank, will produce a greater scour and will more completely wash the interior of the sewer; or, to state it differently, a less amount of water will be needed to remove a given obstruction.

Great stress is laid by the advocates of the separate system upon the more perfect ventilation of the sewers when their size is small, as compared with the ordinary volume of sewage flowing through them.

It is also claimed that organic matter adheres to the upper portions of the interior of sewers of the combined system when they are conveying storm-water, and remains after the storm has ceased, forming a slimy coating; that this soon becomes putrid and promotes the development of swarms of microscopic organisms. On the contrary, it is

claimed that the sewers of the separate system, being filled every day to their maximum working capacity, afford less opportunity for the growth of noxious germs.

A comparison between the separate and combined systems from the financial point of view cannot be made explicitly, as such a comparison must be based upon local circumstances to a certain extent. This much, however, may be said concerning it : —

The cost of a sewer depends upon a number of elements, some of which are independent of the size contemplated ; thus the cost of sheeting and bracing the trench, of pumping water from wet soils, and, to a very large extent, the cost of excavation, back-filling and paving will not be essentially reduced by diminishing the size of the sewer. The difference in cost occasioned by the use of a smaller sewer is, however, generally in favor of the smaller sewer.

A comparison between the cost of a system of combined sewers and of a system of sewers from which surface and subsoil waters are excluded, will generally show that the latter can be built more cheaply. It should be remembered, however, that the greater cost of the combined system is offset by the provisions for the admission and removal of storm-water. If the necessities of the locality require that the surface and subsoil waters shall be removed by underground conduits, their cost should be added to the cost of the house-drainage sewers, in order to make the comparison valid. Should these underground conduits be equal in extent to the system of house-drainage sewers, the cost of the entire combination will usually exceed the cost of a combined system. In most instances the conduits for surface and subsoil water need not be co-extensive with the house-drainage sewers, nor do they need to be placed at so great a depth. Consequently a great many places exist where a separate system would remain the cheapest after the addition of the cost of the necessary channels for removing the surface and subsoil water.

This long quotation has been given as an example of the fairness of spirit with which Mr. Gray has endeavored to consider and to represent the moot questions arising in his discussion. A few of the suggestions, however, may be open to criticism.

Too much importance seems to be given to the foul condition of street wash at the beginning of a storm. The instances which have long been referred to in sanitary literature as proving that the sewage of towns without water-closets is as foul as that from towns with water-closets were, for modern purposes, vitiated by the fact that in the non-water-closet towns referred to a vast deal of household liquid, especially kitchen slops, is discharged through the street sewer. This becomes after decomposition as objectionable as does the discharge of water-closets and it is much greater in quantity. It is hardly fair to suppose that a modern town which is ready to

spend several millions to secure a proper disposal of its sewage would neglect so obvious and important a feature of its cleansing processes as the removal of street dirt, horse-droppings, etc., by some better system than their delivery into public sewers during occasional rain-storms. This "ideal sanitary work" is fast being accepted as rudimentary and indispensable sanitary work. When the question of purifying the outflow of the sewers becomes serious, proper street sweeping will be adopted as a matter of course.

As to the accumulations of snow, ice and filth which adds so much, and so much that is objectionable to the flow of the sewers in winter thaws, they are delivered into streams at a season when they are at least objectionable, and they do not of themselves constitute a sufficient source of nuisance to be regarded as an important factor in the problem.

Not only is the ventilation of the small sewers of the separate system more complete than that of the large sewers, but as the report indicates, the need for ventilation is relatively less, because of the absence of retained putrefactive deposits.

As to the financial comparison made, there is one element of the cost of large sewers which is overlooked: *i. e.*, the cost, where the trenches are in unstable ground, of keeping the work open for the slower process of brick laying. With small pipe sewers, especially with prepared joints, the laying of the conduit occupies so little time that if the bottom can be kept to grade even for a few minutes the pipes can be put in place and the work at once closed in. It is true that the provision for the admission and removal of storm-water in the case of the combined system is of much value, and from the purely financial point of view it may at times, but by no means always, be cheaper to make such provision; but surely, if any subsequent treatment of the sewage becomes necessary, if it is to be pumped or purified chemically, or used for irrigation, the admission of storm-water, — which means the complete pollution of the storm-water — becomes a source of great added cost. The same is true of ground-water which is allowed to find its way into the sewer.

It is not easy to conceive of conditions requiring the sewers for storm-water removal, and the removal of house drainage to be co-extensive, consequently the suggestion that "the cost of the entire com-

bination will usually exceed the cost of a combined system" cannot be accepted as a valid argument. There is no instance recorded of the greater cost of the sewerage of a city by the separate system than by the combined system, and it is doubtful whether one-half of the cost has ever been reached.

In discussing the relative merits of the two chief systems of artificial disposal — chemical purification and irrigation — the tendency of Mr. Gray's arguments and their natural deductions are decidedly in favor of the latter, as an adjunct of "separate" sewering. Whether on the score of cost or of the purity of the effluent, he shows the well-understood advantage of the application of sewage to the soil; but when he comes to make his recommendations his heart fails him, and — leaving his newly-acquired knowledge in abeyance, he advices the chemical system for which, it is true, European experience gives ample precedent — disregarding the serious defects that this experince has shown that system to possess.

The problem presented to Mr. Gray for solution seems to have been this, and only this: To withhold from Providence River and its tributaries the foul matters now carried into them by the outflow of the sewers as at present constructed and as to be extended hereafter. To dispose of underground water or surface water or sewage *as water*, is no part of it; the sole aim is the suppression of the fouling of the streams and bay. In the solution of this problem he seems to have assumed either that it is necessary, or that it is a matter of indifference to diffuse the foul wastes of the city throughout the whole mass of its drainage effluent, including the large amount of subsoil water, — which his guagings show to be an important element of the flow, — the storm-water falling on the covered and uncovered areas of the city, and so much of the water-supply as is used in fountains and elsewhere, as well as that which has already been fouled in its passage through houses, mills, etc.

If any radical criticism is to be made concerning the scheme it must relate to this fundamental part of it.

Argument may be based both on the actual condition of the sewerage of the city, and on its ultimate extension to the complete drainage of the whole area, after its population shall have reached the 300,000 for which provision is made.

He assumes that the total outflow of the sewers will amount then to 58,000,000 gallons per day. This includes 1-100th of an inch of rain-water per hour from the district drained, liquid wastes from manufacturing establishments, amounting now to nearly 5,000,000 gallons per day, and 60 gallons per inhabitant, *including ground-water.*

The present daily dry-weather flow is 3,000,000 gallons. There are about 50 miles of sewers carrying the sewage of 36,421 persons, and this, with the present mill flow is the chief source of the present fouling. To provide only for the purification of the present flow would be unwise. Whether or not it is wise to provide now for the sewage of 300,000 persons depends entirely on the relation between interest on cost, and the cost of added construction when it shall be needed. In discussing the method of disposal adopted by Mr. Gray it is only fair to accept his figures.

The plan is to construct, at a cost of $2,195,973, main and intercepting sewers to collect all drainage of whatever character from all parts of the area under consideration, and to lead the whole to Field's Point, some distance below the city; that is, the whole excepting the excess of storm-water beyond 1-100th of an inch per hour; when this amount is exceeded the surplus is to flow into the rivers, carrying foul sewage with it.

Steam-pumping apparatus is to be provided at a cost of $275,133, capable of lifting 58,000,000 gallons per day to a height of 28 feet.

To these items there should be added for "engineering and contingencies" fifteen per cent, making a total of $2,841,772.

The question now arises whether this effluent may be most efficiently treated by chemical process or by irrigation. Mr. Gray decides in favor of the former for the reason that an acre of land would be required for each one hundred of the population, or 3,000 acres in all; that this land cannot be obtained in a suitable position; and that the cost of sending the sewage to such land as can be obtained would be very serious. He seems to admit that, as we all know, the completeness of purification would be greater if the sewage were applied to the land, but he believes that by chemical process it may be made sufficient.

He therefore provides for tanks, conduits, filter-press, mixing machinery, etc., land, right-of-way, damages, etc., at a cost of $857,732.

It would seem proper to add to this cost the capitalization of the annual cost of working and maintenance. It would be a moderate estimate to fix the cost of pumping at five cents for each million gallons raised one foot high, or $1.40 for each million gallons raised the whole 28 feet provided for. The dry-weather flow is estimated at 60 gallons per person, which for 300,000 population, would make 18,000,000 gallons. Add to this the present mill waste (5,000,000), and we have 23,000,000 gallons to be pumped per day at a total cost of $32.20, or an annual cost of $9,869.30. It would be moderate to estimate the cost of pumping storm-water for a year at $2,140.70 making the total cost of operating the pumps $12,000 annually. The capitalization of this annual payment at four per cent would be $300,000.

The estimate does not refer to the annual cost of the chemical purification of the sewage, but from the indications given, 50 cents per annum per person would be a low estimate. It is the lowest cost suggested in the report. This with a population of 300,000 would make an annual outlay of $150,000, which capitalized at four per cent, would be $3,750,000.

Adding together the estimated cost of construction and the capitalization of the assumed annual working-expenses, we have a grand total of $6,891,772.

Providence is a very rich and prosperous city. It can afford to spend whatever is necessary to secure any needed sanitary improvement and to purify its harbor; but it will hardly rush into an outlay of this magnitude without inquiring carefully whether or not the work can be done for less money.

The claims of the chemical processes of purification have been restated, and fairly set forth in the report. The same can hardly be said of its treatment of the irrigation alternative, where it would have been prudent to go a little deeper than to the mere reports of local engineers and sewage farmers. The general result of the foreign works reported on being taken as a basis, it is assumed, without question, that one acre of irrigation area is required for each 100 of the population, or, for a population of 300,000, 3,000 acres of irrigation area.

There are several things to be considered in this connection: In the first place, a very large proportion of the storm-water falling on

the surface of the town, frequently reported as "all," flows to the irrigation-field, and provision must be made for taking care of it, in spite of the fact that during heavy rains the irrigation-area is already saturated by the same storm that increases the flow of the sewage Another is, that in many cases the amount of land used is greater than is now needed, provision having been made for the future growth of tributary population, and often because the effort is made to derive a profit from the irrigation, for which end the oversaturation of the land even during storms must so far as possible be avoided.

An analysis of the facts and figures of irrigation-farms at once demonstrates the possibility of increasing, to a very considerable extent, the number of persons whose wastes can be taken care of by an acre of land. These facts and figures are a part of the literature of the profession, and one does not need to go personally to Europe to get them.

For example, at Gennevilliers 600 hectares of land (1.482 acres), dispose of 18,000,000 cubic metres (4,950,000,000 gallons) per annum. This is 30,000 cubic metres per hectare or 3,340,081 gallons per acre per annum, that is, 9,151 gallons per acre per day. At 60 gallons per person, being Mr. Gray's estimate of sewage and subsoil water, this is equal to over 150 persons per acre. We happen to have an incidental reference indicating that the soil at Gennevilliers is capable of receiving a much larger amount of sewage, in the report of Marie-Davy's experiment with a large artificial area drained at a depth of six feet. This was covered with growing crops, and it received sewage at the rate of 48,000 cubic metres per hectare per annum. During the six months of the experiment, 24,000 cubic metres of sewage per hectare being applied, only 1,600 cubic metres per hectare reached the drains six feet below the surface. The rest was evaporated by the land and by the crops. This shows that a much larger dose might have been applied. What was applied was equal to 12,576,000 gallons per hectare, or 5,093,117 gallons per acre per annum, being 13,953 gallons per day, giving at 60 gallons per person 232 persons per acre. This can be exceeded.

Mr. Pontzen says, in his report on the sewerage of Havre, "Experience at Gennevilliers has demonstrated that on permeable lands,

the yearly irrigation may reach even to 100,000 cubic metres per hectare."

By the calculation above made, this would give 487 persons per acre.

It is to be borne in mind, however, that the use of sewage at Gennevilliers is entirely at the discretion of the landholders; they use what they want and as they want it. The work is therefore controlled from the agricultural, and not at all from the purification standpoint.

Dr. Frankland, in his experiments on the filtering power of soils with reference to sewage, found that one acre of suitable land devoted to purification without reference to the agricultural result, would dispose of the sewage of 3,300 persons, and Bailey Denton considers it entirely safe to depend upon one-third of this capacity, apportioning the land where purification is the chief object at the rate of 1,100 persons per acre.

All of this shows that it would not be imprudent with a porous subsoil suitably drained to depend on an acre of land to dispose of the sewage of at least 800 persons, being less than one-fourth of Dr. Frankland's limit. This would reduce the area required by Providence after its population shall have reached 300,000 to 375 acres. Therefore it would seem that Mr. Gray has discarded the comparatively inexpensive and perfectly efficient method of irrigation and adopted the very costly and less efficient one of chemical treatment without a full apprehension of present knowledge on the subject. With irrigation, the effluent would reach a high degree of purity; with chemical treatment the purification would probably be sufficient to allow the sewage to be delivered into the river without causing annoyance to the people. Whether or not the delivery of the large amount of chemicals necessarily carried in solution in the effluent, and subjected to the action of the salt sea-water would have an unfavorable effect on the fish and shell-fish of the waters can only be conjectured. Mr. Gray gives us no light on this subject, for he does not tell us which of the many chemical systems he proposes to use.

Were irrigation adopted, the area of land available on the Seekonk Plains (about 1,000 acres) would for many years to come, and doubt-

less for all time to come, allow nearly the whole area to be devoted to remunerative agriculture.

The calculations of the report are based on the assumption that artificial pumping and purification are to be applied to all of the sewage as Mr. Gray advises. All of the manufacturing waste, all of the subsoil-water, all of the rain-water falling on one very large area of the city, and a notable proportion of the rain-water falling on the whole city, without reference to its original condition, is first of all to be made equally foul, then all is to be pumped and all is to be purified.

Is this necessary? If not necessary, is it good engineering or good economy to provide for it? It looks like a sacrifice of public money in the interest of the professional reputation of one who either has failed to acquire the convictions which full knowledge of the subject must create, or has not the courage that such convictions should give.

Mr. Gray has spoken favorably of the separate system of sewerage, as most engineers speak favorably of it, in the abstract. That part of his report which I have italicized would seem conclusive. It is not worth while here to enter into a discussion of the merits or demerits of this system. The report itself accepts it for portions of Providence. Let us see what, if it were applied to the whole city, would be its effect on the serious problem now in hand. Much of the existing system of sewers could be converted into separate sewers without difficulty, and in the construction of the sewerage for the rest of the city the cost would average surely less than half of the cost of combined sewers for the same district.

While many difficult questions would arise as to the disposal of factory waste, street dirt, etc., which are too long to consider here, no one familiar with the business of town sewerage will dispute the proposition that it is practicable to collect all of the filth of the city, which cannot be conveniently removed otherwise, into a system of separate sewers. This being done, the chief factor of the problem is changed from 58,000,000 to 18,000,000, the capacity of the intercepting sewers and of the pumps being reduced by 70 per cent. By leaving the subsoil-water out of the account we should probably lower the chief factor to 12,000,000, and reduce the intercepting and pumping works by nearly 80 per cent. After such reduction let us again

consider the alternative methods of disposal, whether by irrigation or by chemical treatment. Naturally, the cost of chemical treatment would be reduced measurably in proportion to the amount of sewage to be treated. On the other hand, the tax to be imposed on the purifying power of the soil would be very much lessened.

Assuming that there is on the Seekonk Plains 1,000 acres of land available, the entire flow of 18,000,000 gallons per day, could it be evenly distributed over this 1,000 acres, would amount to less than two quarts per square feet of the whole area. The voids of a cubic foot of sand amount to more than two gallons, so that 18,000,000 gallons of sewage evenly distributed over 1,000 acres of sandy land would not saturate it three inches deep. It might be saturated three feet deep — intermittently — without disadvantage.

There exists no precedent, and there is no rule, for determining exactly how large a population can be provided for on an acre of land, if the waters are collected by a strictly separate system, no storm-water and no subsoil-water being admitted. The real tax on the soil is not in disposing of the organic constituents of the sewage, that which the population has added to it, but in getting rid of the water so as to leave its purifying agencies room to act on the filth, it would surely be perfectly safe to say that with 1,000 acres of land available, as on Seekonk Plain, arranged for intermittent delivery onto different areas, only one-third of the whole being in use in any given week or month, 18,000,000 gallons of sewage, containing the wastes produced by a population of 300,000 would be perfectly disposed of with very little interference with profitable agriculture, leaving a fair chance that the irrigation-farm would be able to pay a good part if not the whole of the cost of pumping. The case would be still better with the subsoil-water excluded.

The question whether or not it is premature to provide permanent works for a population so large as 300,000 can be answered better in the community to which it relates than elsewhere. All that it is worth while to say here is that so far as the limit of population can be reduced, in just so far may the cost of disposal by either system and the cost of the construction of permanent works be reduced also.

The data are not at hand on which to base an estimate of the cost of separate sewerage works and irrigation-disposal works to be con-

trasted with the estimate given by Mr. Gray. This, however, may be stated definitely: The separate system is especially applicable to Providence, where there is generally a short and easy means for getting rid of storm-water. If properly applied there to the sewerage of a community of 300,000, with sufficient storm-water sewers, it would not cost in original construction so much as one-half the cost of the combined system. Its maximum outflow, instead of being 58,000,000 gallons per day, would surely not exceed 18,000,000 gallons per day, all surface-water and subsoil-water being excluded. It would probablybe more nearly 12,000,000. This volume of sewage, bearing the filth that it would, could be satisfactorily and economically purified by irrigation.

If the people of Providence are prudent they will investigate this matter very thoroughly before committing themselves to the enormous expenditure contemplated in the report under consideration.

As a rough estimate, hardly even that, but only a shrewd guess, the following figures will probably be safe to put in contrast with the $6,891,772 required to construct and maintain the works that Mr. Gray proposes: —

Probably when their adjacent property is fully occupied, along the 50 miles of sewers now built, the population will be 100,000; for the remaining 200,000, by the same token, 100 miles of sewers would be needed. Combined sewers would cost probably over $20,000 per mile. This would add over $2,000,000 to the grand total, and make it in round numbers say $9,000,000.

The figures for a separate system with irrigation works would not exceed the following: —

Arranging to exclude storm-water from the present lateral sewers, say 40 miles at $2,500	$100,000
Mains to connect these, say 10 miles at $10,000	100,000
100 miles separate sewers with flush-tanks and subsoil drains at $7,500	750,000
20 miles storm-water sewers (following the straightest course to the rivers), at $10,000	200,000
Pumps and buildings	100,000
5 miles force-main and sewer to irrigation-area at $50,000	250,000
1,000 acres, prepared for use, at $1,000	1,000,000
Capitalization of pumping, 12,000,000 gallons, say $8,000 per year (at 4 per cent)	200,000
	$2,700,000

These are very liberal figures, ample to cover all contingent expenses, and leave the completely equipped sewage-farm free of all charge, though it could probably be made to earn one-half if not all of the pumping outlay.

This comparative estimate is of course only offered by way of illustration. Mr. Gray might show that the extension of the combined system would cost less than $20,000 per mile; but on the other hand it is altogether probable that an exact, careful estimate of the whole cost of the alternative work proposed would be less than $2,700,000.

It is quite possible that a careful study of the whole subject might show controlling advantages in the use of the combined system in certain parts of the city, if not in much of it; it is possible that difficulties not here considered might prevent the considerable use of the separate system; it is possible too, that there would be difficulties not apparent without a study on the ground why irrigation would not answer the purpose and why chemical treatment must be resorted to.

These points are not intended to be covered in this review. What is intended is to emphasize the principle that engineers in their public utterances on questions of the importance and magnitude of the one under consideration, where enormous outlay is at stake, and where the permanent interests of a great community are involved, should pay sufficient respect to the intelligence and discretion of their readers to set forth *all* of the controlling facts in the clearest way, and that they should in making their recommendations follow the deductions which flow naturally from their premises as stated.